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Abstract

Purpose: Previous research suggests that many active females are not engaging in sports bra use, despite the positive health benefits. The aim of this study was to establish and compare sports bra use, preferences, and bra fit issues for exercising females in some of the largest and most diverse global underwear markets (US, UK and China). **Design/methodology/approach:** A survey covering activity levels, sports bra use and preferences, bra issues, and demographics was administered via Qualtrics and completed by 3147 physically active females (aged ≥ 18 years) from the US (n=1060), UK (n=1050) and China (n=1037). **Findings:** In general, participants were 25 to 29 years, 121 to 140 pounds, 34B bra size, and pre-menopausal. '*I can't find the right sports bra*' was the most frequent breast barrier to exercise (25.4%). Three-quarters of women wore a sports bra during exercise, with significantly higher use in China (83.9%), compared to the UK (67.2%). A third of all participants reported sports bra shoulder straps 'digging into the skin'. Sports bra preferences were; compression sports bras, with a racer back, wide straps, thick straps (in US and UK), thin straps in (China), adjustable straps and underband, no wire, maximum breast coverage (in US and UK), including nipple concealment, and with padded/moulded cups. **Originality/value:** Information provided on differences in sports bra use, preferences and bra issues across three major global markets could

be utilised by brands and manufacturers to optimise bra marketing and fit education initiatives, and inform future sports bra design and distribution strategies.

Keywords: consumer behaviour, consumer preferences, brands, sports bra, bra fit, bra design, breasts, international markets, female apparel

Introduction

The global women's activewear market is growing year on year, recording a total revenue of approximately $119 billion in 2017 and forecast to reach almost $217 billion by 2025 (O'Connell, 2019). The sports bra market record a revenue of $9 billion in 2019 and is expected to reach $38.4 billion by 2026, representing significant growth (WinterGreen Research, 2020). The US dominates the global sports bra market, with 45% of female consumers shopping for or purchasing a sports bra in 2018, compared to 38% in 2015 (NPD, 2019). However, statistics also indicate increased demand for sports bras in other regions, with the UK increasing its sports bra stock by 17% since 2018 (Marci, 2020), and the Asia-Pacific region expected to show the fastest growth rate (9.6%) in the women's activewear market, during the forecast period 2018-2025 (Bhandalkar & Das, 2018). Understanding bra consumer needs in these dominant regions and the value consumers attach to certain bra attributes when making a purchase decision is important to optimise consumer offering, and develop effective marketing and promotion activities. The growth of the global sports bra market is driven by increased female participation in sports and exercise and increased awareness the need to support the breast (O'Connell, 2019). The breast has limited intrinsic support and as a consequence excessive breast movement can occur during physical activity (Page & Steele, 1999; Scurr, White, & Hedger, 2009, 2011). This movement has been reported to range from 4 cm during walking to 15 cm when running (Bowles, Steele, & Munro, 2008; Scurr, White, & Hedger, 2011). Repeated loading on the delicate breast supporting structures, due to excessive breast motion, may result in breast discomfort, breast sag and embarrassment (Bowles *et al*., 2008; Mason *et al*., 1999; Page and Steele, 1999; Starr *et al*., 2005). Up to 72% of exercising females (Gehlsen & Albohm, 1980) are reported to experience breast pain and, despite the success of

55 the global sports bra market, one in five adult women (Burnett et al.,2015) and over half of
56 adolescent girls (Scurr et al., 2016) report the breast as a barrier to exercise.
57
58 Well-designed sports bras are more effective in limiting breast motion than standard fashion
59 bras or crop tops (Boschma, Smith & Lawson, 1996; Bowles et al., 2008; Bowles, Steele, &
60 Munroe, 2012; Mason et al., 1999; Page & Steele, 1999) and are advocated to reduce breast
61 motion and discomfort during physical activity (Mason *et al*., 1999; Scurr *et al*., 2010; Scurr
62 *et al*., 2011; White *et al*., 2009; White *et al*., 2011). Currently, there are three distinct sports
63 bra designs on the market: compression, encapsulation, and combination. Compression sports
64 bras typically pull over the head, do not have cups and restrict breast motion by compressing
65 the breast to distribute their mass across the chest wall (Page & Steele, 1999; Starr et al., 2005).
66 Encapsulation sports bras support each breast individually in separate, structured cups to limit
67 breast movement (Page & Steele, 1999; Starr et al., 2005). Compression bras both encapsulate
68 and compress the breasts, although in varying degrees dependent on the sports bra design. In
69 addition to these bra types, there is also a wide variation in sports bras features such as closure
70 methods, strap configurations, cup styling, and adjustability options (Page & Steele, 1999;
71 Zhou, Yu & Ng, 2012). Understanding how consumers perceive these particular bra attributes
72 is important for the bra industry to optimise consumer satisfaction. However, to date there is
73 limited information surrounding sports bra preferences.
74
75 Despite the growth in the sports bra market, and increased understanding of breast support
76 requirements, research has identified that sports bra use among female populations is low. In
77 the UK Scurr *et al*. (2016) identified that over half of 2089 adolescent girls surveyed reported
78 never wearing a sports bra during sport and exercise. In China, only 40% of 404 women
79 surveyed had ever worn a sports bra; sports bra usage was affected by age, breast size and

monthly income (Chen *et al*., 2019). Bowles *et al*. (2008) reported that among adult populations in Australia sports bra use was as low as 41%. Many Australian females were more likely to wear an everyday bra during physical activity regardless of their age or bra size, highlighting a lack of engagement in sports bra use. Bowles *et al*. (2008) proposed that this finding suggested consumers may be dissatisfied with current sport bra designs and recommended that more attention should be placed upon aspects of sports bra design that are important to consumers. This finding was echoed by Burnett et al., (2015), who reported that breasts were a barrier to physical activity participation for 17% of women in the UK, with the most influential breast related barrier to being 'I can't find the right sports bra'. This suggests that the current bra market may not provide appropriate breast support options. Engagement in sports bra use by women in the US is currently unknown, despite the US dominating the global sports bra market.

Secular differences in breast size exist across different countries (Brown and Scurr, 2016) and breast size is known to influence sports bra use, preferences and fit (Brown *et al*., 2014). Thus it is plausible that these factors may differ between countries, particularly as research recognises that socio-cultural factors are influential in consumers purchasing behaviour (Koca and Koc, 2016). In a review of breast size across different countries, Brown and Scurr (2016) reported some of the smallest bust circumferences in a Chinese population and some of the largest bust circumferences in a US population, with the UK positioned between China and the US. Larger-breasted women are reported to experience more bra fit issues due to the large range of breast mass and volume within a bra size making identifying an appropriate bra more challenging (McGhee *et al*., 2013). Rubbing and chaffing, shoulder straps digging in, upper body pain, and poor posture were bra issues experienced significantly more frequently by participants with larger breasts compared to those with smaller breasts (Brown *et al*., 2014;

Burbage and Cameron, 2018). Furthermore, Brown *et al*. (2014) reported that sports bra use was more frequent and perceived as more important in larger-breasted women (≥D cup). In China, women with larger breasts were also more likely to wear sports bras (Chen *et al*., 2019). It is important to further investigate factors that both encourage and deter women from wearing sports bras, particularly those factors related to sports bra design and fit, so that sports bras can be modified accordingly within each market. This may increase their use, potentially increasing the number of women exercising, in addition to offering commercial benefit to manufacturers through increased sales. Obtaining correct bra-fit can be problematic for females with 70 to 100% of women reported to be wearing incorrectly fitting bras (Greenbaum, Heslop, Morris, & Dunn, 2003; McGhee & Steele, 2010b; Pechter, 1998; Wood, Cameron & Fitzgerald, 2008). Research has found the traditional method of a tape measurement to establish bra size to be unreliable, with this method overestimating the underband size in 76% of cases and underestimating the cup size in 84% of cases (White & Scurr, 2012). Literature now suggests that females should be educated on professional bra fitting criteria to improve their ability to independently choose a well-fitted bras (Brown et al., 2018; Boschma, Smith & Lawson, 1996; Chen et al., 2019; McGhee & Steele, 2010; McGhee, Steele & Munro; White & Scurr, 2012), although to date limited research has investigated sizing methods employed when purchasing sports bras.

Regardless of the growth in the sports bra market, previous research suggests that a percentage of active females are not engaging in sports bra use, despite the positive health benefits. Furthermore, a high proportion of women experience fit issues relating to their sports bras and cite the breast as a barrier to exercise. The US, UK and China represent the three regions with the largest share in the global sports bra market and whilst literature exists highlighting sports bra use, preferences and fit in the UK, limited data has been located for China and there is no

information for the US. Additionally, research indicates that these market regions may differ with regard to breast size and it is recognised that socio-cultural factors may influence purchasing behaviour. Therefore, in order to inform general and specific sports bra market requirements, this study aimed to 1) establish breast-related barriers to physical activity, sports bra use, preferences, and fit issues of exercising females in some of the largest and most diverse underwear markets in the world (US, UK and China and 2) identify how these factors differ between these markets.

Methods

Setting and Sample

This study had a cros-sectional survey design. Following full institutional ethical approval, an on-line survey was administered via Qualtrics software to a sample of US, UK and Chinese nationals. On-line surveys offer an increased sense of privacy resulting in high data quality, in addition to allowing respondents to complete the survey at their convenience (Vehovar and Manfreda, 2008). The surveys were distributed to participants in the US, UK and China between March 2017 and October 2018 via an email invitation; the survey distribution was not limited to specific regions within these countries. Participation was voluntary and participants were free to withdraw at any point up until the final submission of survey responses. All data were anonymous. A double opt-in process was used by Qualtrics; this consisted of a registration process (participants are recruited by various methods, such as online portals, in-app messaging, SMS and targeted email invitaitons) and then an email invitation to complete the survey if participant's basic registration data matched the inclusion criteria; female, ≥18 years, living in the US, UK or China, and physically active two or more days a week. In return for survey completion, participants received points, which could be redeemed in a number of ways, for example as gift cards or store credit.

Survey Development

A custom four-part, forty-question survey was developed based on a breast survey previously utilised in a general population (Burnett *et al*., 2015). Questions on demographics, breast and bra issues, barriers to exercise and physical activity levels were taken from Burnett et al.'s (2015) paper; more detailed questions on sports bra preferences were created for the current study. At the beginning of the survey participants were provided with an information sheet that explained the nature of the investigation. Completion of the survey was considered as consent to participation in the study and at no point were participants asked for their name and/or contact details. Section one of the survey identified participant's barriers to physical activity and their levels of moderate- and vigorous-intensity activity; moderate-intensity activities were defined as activities that require moderate physical effort and cause small increases in breathing or heart rate, vigorous-intensity activities were defined as activities that require hard physical effort and cause large increases in breathing or heart rate. Section two explored sports bra use and bra preferences of exercising females. Section three of the survey captured information about bra and breast issues exercising females experienced. The final section identified demographic data and information about breast health history. The survey contained closed questions (tick box), and was designed to take no more than 15 minutes to complete. Minor alterations to some questions were made to ensure they were culturally relevant to each target demographic, for example amending the types of exercise listed, and amending questions to include relevant currency. Prior to distribution in China, the English survey was translated into Mandarin Chinese, the official and standard spoken language in mainland China.

Responses were automatically downloaded to Microsoft Excel (2010) from Qualtrics and data were checked for accuracy. Of the 3154 completed surveys, three cases were removed due to respondents not meeting the inclusion criteria (female and exercising ≥ twice a week), and one

case was removed due to nonsensical responses. Listwise deletion, pairwise deletion and imputation can be used to handle incomplete data (Rafiq and Jaafar, 2007). Due to multiple missing responses, these three cases were removed from the data set (listwise deletion). The remaining cases had very few data missing (< 2.5%), thus pairwise deletion was used, meaning these cases were temporarily removed from the analysis only in respect of those entries for which there was no response. This resulted in a final sample size of 3147 for all subsequent analyses, comprised from the US (n = 1060), the UK (n = 1050) and China (n = 1037).

Descriptive and inferential analyses were carried out using Predictive Analytic Software Statistics version 24.0 (SPSS, Hong Kong) and the alpha level for inferential analysis was set at 0.05. Data were analysed descriptively to summarise participant's demographic profiles and breast history. When participants were asked to rank the importance of sports bra features (e.g. 1 = most important, 10 = least important) Friedman tests were applied to establish mean ranks, with a lower mean rank indicating higher importance.. Physical activity data were positively skewed towards low levels, therefore differences in physical activity data between countries were assessed using Kruskal Wallis H tests. Differences between countries in all other nominal or ordinal variables were assessed using the Chi-square test of homogeneity. Where significant differences between countries were identified, post hoc analysis involved pairwise comparisons using the z-test of two proportions with a Bonferroni correction.

Results

Demographics

The mode age range was 18 to 29 years in the US (35.9%), UK (31.0%) and China (33.6%). The mode body mass range for both the US (25.3%) and UK (26.0%) was 55 to 64 kg, compared to 45 to 54 kg (38.9%) in China. The majority of participants were pre-menopausal

(64.3%) although a significantly higher proportion of post-menopausal women participated in the US (28.6%) compared to the UK (22.1%) and China (20.0%). The proportion of women who had given birth was significantly higher in China (68.2%) compared to the US and UK where proportions were similar (57.8% and 59.5%, respectively) ($\chi2(2) = 27.321$, $p < 0.001$). Of those who had given birth (n = 1944), 69.7% reported breastfeeding. In all countries the mode bra size was a 34B (Table I). Almost half of UK participants had a breast cup size ≥ D, which was significantly higher than the US (34.5%) and China (5.0%) ($\chi2(2) = 470.356$, $p < 0.001$). Women with underband sizes ≥ 40 inches ranged from 6.8% in China, to 15.5% in the US.

Table I near here

Barriers to physical activity

On average, participants participated in moderate physical activity for 3.7 ± 1.7 days per week, and vigorous physical activity for 2.3 ± 1.9 days per week. There were no differences in moderate physical activity participation between countries ($\chi2(2) = 4.788$, $p = 0.091$), however vigorous physical activity participation was higher in the UK, and lower in the US, compared to China ($\chi2(2) = 73.978$, $p < 0.001$). Walking/hiking was the most popular activity among US (74.6%) and UK (58.5%) participants, whereas running was most popular in China (57.3%), followed by walking/hiking (38.7%).

Of the breast-related barriers to physical activity (Table II) '*I can't find the right sports bra'* was ranked highest (8/24 barriers), affecting 25.4% of participants. *'I don't like the look of my breasts'* was the second highest ranked breast barrier (22.0%), with more UK participants (23.6%) reporting this as a barrier compared to US participants (19.1%) ($\chi2(2) = 8.010$, $p =$

0.018). Nearly a quarter (23.4%) of Chinese participants reported being embarrassed by breast movement compared to UK (18.3%) and US (14.4%) participants ($\chi2(2) = 27.437$, $p < 0.001$).

Table II near here

Sports bra use and purchasing habits

In the UK, less participants wore a sports bra to exercise (67.1%) compared to the US (77.5%) and China (83.9%) ($\chi2(2) = 78.833$, $p < 0.001$). Half of US (53.3%) and UK (50.1%) participants 'always' wore a sports bra during exercise (Table III), which was higher than in China (28.6%) ($\chi2(2) = 137.380$, $p < 0.001$). More than 80% of all participants rated sports bra use as *'essential'* or *'very important'* (Table III).

Most participants reported that they wore a sports bra (Table III) because it '*enables me to exercise in comfort'* (69.6%), although this was higher in US participants (76.1%) compared to Chinese and UK participants ($\chi2(2) = 24.883$, $p < 0.001$). Interestingly, compared to US and UK participants, less Chinese participants (46.0%) reported wearing a sports bra to *'reduce breast movement'* ($\chi2(2) = 130.996$, $p < 0.001$), and more wore a sports bra as it is *'less embarrassing'* (38.0%) ($\chi2(2) = 63.352$, $p < 0.001$). Over a third (35.1%) of all participants wore a sports bra to 'reduce breast pain'. Almost four times as many Chinese (38.0%) reported wearing a sports bra because it *'matches my sportswear'*, compared to US and UK participants ($\chi2(2) = 232.210$, $p < 0.001$).

Table III near here

Compared to US and UK, more participants in China reported wearing an everyday (fashion) bra under their sports bra (30%; $\chi2(4) = 130.000$, $p < 0.001$), or wearing two sports bras during exercise (9.8%; $\chi2(4) = 25.406$, $p < 0.001$) (Table III). The majority of US (78.9%) and UK (82.3%) participants wore the same sports bra for all activities, compared to 44.3% of Chinese participants ($\chi2(2) = 329.440$, $p < 0.001$) (Table III).

Twice as many Chinese participants purchased a sports bra '*in the last month'* (46.6%) (Table IV), compared to US (22.6%) and UK (21.0%). Chinese participants replaced their sports bras more regularly; 51.7% replacing them every 3 months, compared to 11.4% and 15.0% of US and UK participants ($\chi2(10) = 538.945$, $p < 0.001$). US participants most commonly own two to three sports bras (31.3%) with UK and Chinese participants owning three to four (46.1%), and four to five (44.6%). Around a third of US (37.5%) and UK (35.7%) participants would spend ≤ 20 USD on a sports bra, compared to ≈30 USD reported by 19.9% of Chinese participants.

Table IV near here

More US participants (68.6%) purchased sports bras from department stores compared to UK (42.6%) and China (43.6%) ($\chi2(2) = 137.104$, $p < 0.001$), whereas more Chinese participants purchased sports bras from sports apparel stores (68.4%) ($\chi2(2) = 317.866$, $p < 0.001$) (Table IV). Online purchases were more popular in the UK (42.6%) and China (44.5%) compared to the US (31.9%) ($\chi2(2) = 317.866$, $p < 0.001$).

Sports bra preferences

Compression style sports bras were most frequently worn (48.2%), followed by combination (26.7%) and then encapsulation style bras (14.8%). Encapsulation bras were less popular among US participants (9.2%), with more than twice as many US participants wearing a mixture of different styles compared to the UK and China ($\chi2(7) = 70.456$, $p < 0.001$). The majority of participants preferred racer back style (58.0%), which was significantly more popular in US participants (63.9%) ($\chi2(2) = 17.685$, $p < 0.001$) (Table V).

Most participants preferred wide (60.1%), thick (padded) (40.0%) sports bra straps with adjustability (58.2%) (Table V), although thin (padded) straps were the dominant choice among Chinese participants (45.4%). Non-wired sports bras were more popular among US participants (73.6%; $\chi2(4) = 30.997$, $p < 0.001$), with the Chinese preferring padded/moulded cups (62.6%; $\chi2(4) = 129.567$, $p < 0.001$). There was a clear preference for nipple concealment among all participants, however more US and UK participants preferred maximum coverage (64.8% and 71.5%, respectively), compared to the majority of Chinese participants who did not want maximum coverage (68.6%) ($\chi2(6) = 1446.545$, $p < 0.001$). Around a third of participants in each country reported no preference when considering sports bra colour (Table V), although among UK participants black sports bras were significantly more popular (32.3%), and multi-coloured sports bras less popular (17%), compared to those in the US and China ($\chi2(10) = 55.640$, $p < 0.001$). Less than 10% of participants in each country expressed a preference for white, nude, or bright neon coloured sports bras.

Table V near here

During moderate and vigorous activity *Comfort, Support* and *Fit* were the top three rated sports bra features in all countries, (Table VI). *Brand* and *Colour* were consistently ranked the least important sports bra features. During moderate intensity activities, *Price* was less important in China (ranked 9th) compared to US and UK (ranked 4th), although during vigorous intensity activities was deemed more important (ranked 6th)(Table VI). Nike™ was the most popular sports bra brand in each country (Table VII).

Table VI near here

Table VII near here

Sports bra fit issues

Most US (65.6%) and UK (64.1%) participants had never been professionally fitted for a sports bra (Table IX) compared to 21.6% in China ($\chi^2(12) = 800.942$, $p < 0.001$). Around one fifth of participants sports bra's did not meet their exercising needs, with no differences observed between countries ($\chi2(2) = 1.317$, $p = 0.518$). The most common fit issue was *'shoulder straps dig into the skin'* (Table VIII). The bra fit issues *'rubbing or chaffing'* was reported by more Chinese participants (33.6%) than US and UK participants ($\chi^2(2) = 20.242$, $p < 0.001$).

Table VIII near here

Discussion

The aim of this research was to establish and compare breast-related barriers to physical activity, sports bra use, purchasing habits, sports bra preferences and sports bra fit issues in three major global underwear markets (UK, US and China). Within these three populations, mode bra size (34B) was the same, supporting previous UK and Chinese research (Burbage and Cameron, 2017; Chen *et al*., 2019). Despite this, nearly half (48.7%) of UK participants

were large-breasted (≥ D cup). More US participants wore larger band sizes (≥40 inches), supporting reports of secular increases in US and UK bust circumferences (Brown and Scurr, 2016). Interesting trends in bra sizing are visible, with UK participants wearing smaller band sizes, but a larger range of cup sizes, US participants wearing larger band sizes, but a smaller range of cup sizes, and Chinese participants wearing smaller band and smaller cup sizes. However, these outcomes should be viewed with caution as reported bra sizes may reflect the availability of sizes, rather than the sizes required and the majority of US and UK participants reported never having their sports bra fitted and reported fit issues. Additionally, self-reported bra sizes may be inaccurate (Greenbaum *et al*., 2003; McGhee and Steele, 2010; White and Scurr, 2012), in fact 35% of Chinese participants surveyed by Chen *et al*. (2019) did not know their bra size.

More UK participants undertook vigorous activity each week, despite reporting larger cup sizes than the US and China. Not being able to find the right sports bra was the highest breast-related barrier to activity, suggesting the current market is not meeting consumer needs. '*I can't find the right sports bra*' was previously reported as the highest breast-related barrier to exercise for UK participants (Burnett *et al*., 2015), although prevalence was much lower (3%), compared to this study (24.9%). This may suggest that not being able to find the right sports bra is even more of an issue now than in 2015. This may have health implications for women who are reported to avoid exercise due to breast discomfort, breast sag and embarrassment caused by breast motion (Bowles *et al*., 2008; Mason *et al*., 1999; Page and Steele, 1999; Starr *et al*., 2005). Interestingly many more Chinese participants were embarrassed by the appearance of their breasts during exercise, despite smaller ranges of cup and band sizes, suggesting that this might be due to cultural differences, rather than larger breast sizes. The increased sensitivity of Chinese participants to their breast appearance during exercise may

354 impact the type of bra appropriate for this market and should be considered by product
355 developers when designing sports bras for this population.
356
357 Sports bra use was lowest in the UK (67.1%) and highest in China (83.9%), signifying that
358 more needs to be done in the UK to increase awareness of wearing appropriate breast support
359 during exercise. Although a smaller study (n = 404) in China only reported a 40% uptake of
360 sports bras (Chen *et al*., 2019); this may be due to differences in socioeconomic status, age and
361 breast size between populations surveyed. Interestingly, only 28.6% of Chinese participants
362 always wore a sports bra during exercise and less Chinese participants rated sports bras as
363 essential, despite owning more bras and paying more for their sports bras than US and UK
364 participants.
365
366 The greatest motivation to purchase sports bras across all countries was to exercise in comfort.
367 More UK participants wore a sports bra to reduce breast movement, perhaps related to the
368 larger cup size ranges reported in the UK. Interestingly, almost four times more Chinese
369 participants wore a sports bra because it matched their sportswear. This may have implications
370 for brands active in the Chinese market, suggesting that the sports bra should not be viewed as
371 a product in isolation, but should be designed and marketed alongside other sporting apparel.
372 Worryingly almost 30% of Chinese participants wore an everyday bra under their sports bra,
373 and nearly 10% wore two sports bras to exercise. As less Chinese participants wore a sports
374 bra to reduce breast movement this behaviour may be due to embarrassment when exercising.
375 Although it has been reported that a single, well fitted and supportive bra can considerably
376 reduce embarrassment when exercising (Scurr *et al*., 2011). More US (78.9%) and UK (82.3%)
377 participants wore the same sports bra for all activities compared to Chinese participants
378 (44.3%). Research has promoted sport-specific bras due to biomechanical variations across

activities such as running, jumping and agility-tasks (Risius *et al*., 2014), yet cost may be prohibitive. Chinese participants owned more sports bras, had purchased them more recently and replaced them more frequently; this may be linked to price being one of the lowest ranked sports bra features among Chinse participants. To increase purchasing behaviours in more price sensitive regions such as the US and UK, retailers could consider stocking lower priced products or offering more promotions to these regions. Although differences in price sensitivity should be viewed with caution due to differences in the cost of living between countries, and as participant's socioeconomic status was unknown. Bra purchase locations also varied between countries indicating different purchasing habits that may further affect marketing and education strategies; notably, participants in the US favoured department stores (69%), sports apparel shops in China, and supermarkets in the UK. Overall, 40% of participants purchased sports bras online.

In all countries, compression sports bras were most popular. However, a lack of adjustability in these garments is a criticism, and as compression bras are pulled on and off over the shoulders they may stretch reducing their lifespan. The style worn may however be reflective of availability rather than choice. Shoulder straps digging in or slipping off were the most disliked features of sports bras (Bowles *et al*., 2012), which may be why more participants preferred racer-back (58%) or cross-over styles which avoid these issues. Most preferred wide sports bra straps, although more US and UK participants wanted thick (padded) straps in contrast to Chinese participants who preferred thinner straps. Non-wired sports bras were preferred across all countries. If such a bra does not fit correctly and underwire digs in, it will be uncomfortable, which may deter use (Bowles *et al*., 2012). More Chinese participants preferred padded/moulded cups compared to the US and UK, which is concurrent with Chinese participants desire for nipple concealment. Although, interestingly, most Chinese participants

404 did not prefer a sports bra with maximum coverage, despite embarrassment due to excessive
405 breast movement being a larger exercise barrier for Chinese participants. This suggests that
406 sports bra styles in China need to conceal the nipple, but not provide too much coverage of the
407 breast/chest; these preferences are despite previous Chinese research, which concluded the
408 most effective sports bras had a high neckline and no padding (Zhou *et al*., 2012). The
409 combination of functionality, comfort and fashion requirements creates increased challenges
410 for product developers and designers (Dhanapala, 2015). The findings of the current study
411 provide insight into some of the requirements for sports bra design and how these may differ
412 across the three markets investigated here.
413
414 For all participants, comfort was the most important sports bra feature, corresponding with
415 previous UK research (Risius *et al*., 2014). Support was the second highest sports bra feature
416 desired by UK and US women, although material was more important than support in China,
417 which may reflect the smaller range of breast sizes in this population. Fit was the third highest
418 feature for all countries; despite this, many participants reported sports bra fit issues. To meet
419 consumer needs, and provide sports bras that are comfortable, supportive and fit appropriately,
420 future research is needed to guide breast support and bra design for exercising females. Overall
421 Nike™ had the largest sports bra market share (40%), followed by Adidas™ (28%), which is
422 reflective of their global dominance in the sports apparel industry. However, a wide range of
423 brands were reported, but Brand was ranked very low as a sports bra feature (8th to 10th out of
424 10 features), suggesting that participants are not necessarily loyal to particular sports bra
425 brands.
426
427 Most UK (64.1%) and US (65.6%) participants had never been professionally fitted for a sports
428 bra, which corresponds to previous UK research (Brown *et al*., 2014; Burbage and Cameron,

2018). In contrast, over half of Chinese participants were professionally fitted for a sports bra in the last month, or last three months. It would be useful to understand how sports bra fittings are promoted in China, and why the uptake is much higher, although this may be explained by the majority of Chinese participants purchasing sports bras from sports apparel shops specifically, Despite the increased prevalence of sports bra fittings in China, more Chinese participants experienced sports bra fit issues, suggesting the fitting processes could be improved. Traditional tape measure bra fitting was the most popular fitting method (58.5%), however, this method is reported as inaccurate (White and Scurr, 2012) and instead professional best-fit criteria are promoted (McGhee and Steele, 2010; White and Scurr, 2012); ensuring participants have the knowledge to assess their own bra fit.

Limitations

This study has inherent limitations, which offer directions for future research. Firstly, the study is restricted to comparing US, UK and Chinese consumers. Future studies could extend the scope to include consumers from other countries. Secondly, other factors such as age, ethnicity, breast size and socioeconomic status were not included in the analysis. Future studies may seek to develop methods to evaluate the influence that these variables have on sports bra use, preferences and fit, which were beyond the scope of this study.

Conclusion

This is the first study to compare breast-related barriers to physical activity, sports bra use, purchasing habits, sports bra preferences and sports bra fit issues across large samples in the UK, US and China. Across the three markets, the most preferred sports bras were compression style, with a racer-back, non-wired and wide straps. In China participants had a smaller range of breasts sizes, purchased the most sports bras and were more likely to wear multiple bra

products whilst exercising. Thin straps, padded/moulded cups and nipple concealment was preferred. US participants reported larger band sizes and preferred a racer-back, non-wired compression style sports bra, with thick, padded straps and maximum coverage. UK participants reported larger cup sizes yet were least engaged in sports bra use. Reducing breast movement was perceived as the most important function of a sports bra, although participants generally owned just one sports bra and wanted maximum breast coverage. Not being able to find the right sports bra was the 8th (out of 24) highest barrier to exercise for all countries. Sports bras were purchased to exercise in comfort. This study has reported interesting differences in barriers to exercise across key global sports bra markets, with substantial differences in sports bra use, purchasing habits, preferences and fit. The bra industry should use this country-specific information to better understand consumer needs and target sports bra design within each of these countries.

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588 **Table I.** Distribution of US, UK and China participants self-reported bra size (underband and cup)

589 (n = 2869). Mode size highlighted.

Underband (inches)	Cup size												
	AA	A	B	C	D	DD/E	DD D/F/FF	G/G G	H/H H	J	K	L	Total
24			1										1
26													0
28				1									1
30				1	1	1	1						4
32			15	35	32	14	5	2					103
34			26	120	85	44	22	5					302
36			11	66	114	43	24	10		2			270
38			3	28	57	48	24	5					165
40			1	6	15	22	13	2					59
42				3	11	12	7	5	1		1		2	42
44				2	7	7	12	5	1	1				35
46					1	1	2	1	1					6
48				1	1	1	5							8
50						2		1						3
52					1			1						2
54														0
56														0
58														0
Total	0	57	263	325	195	115	37	3	3	1	0	2	1001
24													0
26													0
28						2							2
30		2	3		1	3	3		1				13
32	3	26	37	25	18	23	4	1	2	1			140
34		22	93	76	50	59	15	10		1			326
36		11	58	79	61	53	7	4	2	1			276
38		2	19	22	34	35	7	6					125
40		1	5	13	17	21	9	3	2				71
42			2	2	6	5	2		1				18
44			1	2	2	4	1	1					11
46													0
48											1		1
50						1							1
52					1								1
54											1		1
56			1										1
58					1								1
Total	3	64	219	219	191	206	48	25	8	3	2	0	988
24													0
26				1									1
28		7	6	1									14
30		19	28	9	1								57
32		49	64	41	5	1							160
34		45	151	113	11	3							323
36		20	92	74	11								197
38		7	24	31	6								68
40			1	6	1								8
42			2	27	1								30
44				1									1
46				15									15
48				2									2
50		1		1									2
52			1										1
54													0
56													0
58				1									1
Total	0	148	369	323	36	4	0	0	0	0	0	0	880

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591 **Table II.** Percentage of the population who report each barrier to physical activity and the rank order
592 of each barrier reported in the US (n = 1060), UK (n = 1049†) and China (n = 995†)

Barrier to physical activity	Response (%)				$\chi 2$
	US (n = 1060)	UK (n = 1049*)	China (n = 995†)	All (n =3104†)	
I need to rest or relax in my spare time	36.1[3a]	40.4[2a]	51.7[1 b]	43.3[1]	71.017*
I'm not the sporty type	44.2[1a]	43.5[1a,b]	22.4[11a]	37.0[2]	133.570*
There's no one to do it with	35.8[4a]	34.1[5a,b]	30.1[2b]	33.4[3]	8.126*
I haven't got the energy	42.0[2a]	34.7[4b]	22.0[12c]	33.1[4]	94.204*
I haven't got the time	32.5[5a]	37.2[3a]	27.4[5b]	32.5[5]	22.100*
I'd never keep it up	32.2[6a]	30.7[6a]	25.4[6b]	29.5[6]	12.228*
I've got young children to look after	28.0[8a]	31.2[7a]	27.6[4a]	29.0[7]	3.797
I can't find the right sports bra	28.8[7a]	25.1[11a,b]	22.0[12b]	25.4[8]	12.472*
I'm too shy or embarrassed	25.8[9a]	31.2[7b]	17.8[14c]	25.1[9]	49.226*
I don't have time because of my work	20.9[11a]	25.3[10b]	27.5[3b]	24.9[10]	16.445*
I don't like the look of my breasts when I exercise	19.1[17a]	23.6[12b]	23.3[10a,b]	22.0[11]	8.010*
I can't afford it	25.7[10a]	28.5[9a]	10.9[20b]	21.9[12]	165.570*
I haven't got the right clothes or equipment	20.1[12a,b]	19.3[15a]	24.0[8b]	21.1[13]	7.888*
I am too fat	20.0[14a]	22.4[13a]	15.3[18b]	19.3[14]	17.160*
My breasts are too big	19.2[16a]	20.0[14a]	16.4[15a]	18.6[15]	4.846
I am embarrassed by excessive breast movement	14.4[19a]	18.3[17b]	23.4[9c]	18.6[16]	27.437*
There are no suitable facilities nearby	13.8[20a]	15.1[20a]	25.2[7b]	17.9[17]	54.417*
My health is not good enough	16.1[18a]	18.7[16a]	15.0[19a]	16.6[18]	5.351
I don't enjoy physical activity	19.9[15a]	17.8[18a]	9.9[21b]	15.8[19]	41.710*
I have an injury or disability that stops me	20.1[12a]	17.1[19a]	7.3[22b]	15.0[20]	70.985*
I suffer with breast pain	10.0[23a]	13.0[22a,b]	16.2[16b]	13.0[21]	17.356*
I might get injured or damage my health	10.3[22a]	12.1[23a,b]	15.5[17b]	12.6[22]	12.907*
I'm too old	10.8[21a]	13.3[21a]	7.0[23b]	10.4[23]	21.927*
Other	5.2[24]	5.2[24]	6.2[24]	5.5[24]	

593 †one participant from the UK and 45 participants from China did not provide responses.

594 Barriers highlighted grey are breast specific barriers. Superscript numbers denote the rank order of
595 barriers reported.

596 *denotes significant difference between countries at 0.05 level. Values in the same horizontal row not
597 marked with the same superscript letter are significantly different at 0.01 level

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Table III. For participants that reported wearing a sports bra, the frequency, perceived importance and reason for sports bra use during exercise in the US (n = 795), UK (n = 705) and China (n = 870).

	Response (%)				χ^2
	US (n = 795)	**UK (n = 705)**	**China (n = 870)**	**All (n = 2370)**	
Frequency of sports bra use					
Rarely	2.9[a]	4.4[a]	4.0[a]	3.8	
Sometimes	18.5[a]	20.7[a,b]	23.6[a]	21.0	137.380*
Very Often	25.3[a]	24.8[a]	43.8[b]	31.9	
Always	53.3[a]	50.1[a]	28.6[b]	43.3	
Perceived importance of sports bra use					
Not at all important	1.9[a]	1.7[a]	1.0[a]	1.5	
Somewhat important	14.3[a]	12.3[a]	14.6[a]	13.8	38.447*
Very important	36.7[a]	40.4[a]	49.5[b]	42.5	
Essential	47.0[a]	45.5[a]	34.8[b]	42.1	
Reason for sports bra use					
Enables me to exercise in comfort	76.1[a]	65.1[b]	67.2[b]	69.6	24.883*
Reduces breast movement	70.4[a]	68.9[a]	46.0[b]	61.0	130.996*
Reduces breast pain	32.6[a]	37.2[a]	35.9[a]	35.1	3.753
Less embarrassing	21.0[a]	25.7[a]	38.0[b]	28.6	63.352*
It improves my sporting performance	23.0[a]	21.1[a]	38.4[b]	28.1	72.688*
I like the way it looks	25.7[a]	18.9[b]	24.7[a]	23.3	11.211*
Matches my sportswear	13.0[a]	9.9[a]	38.0[b]	21.3	232.210*
I don't know	1.8[a]	2.3[a]	1.0[a]	1.6	3.768
Wear an everyday (fashion bra) under sports bra					
Yes	10.8[a]	13.3[a]	28.4[b]	18.0	
No	79.1[a]	74.0[a]	55.9[b]	69.0	130.000*
Sometimes	10.1[a]	12.6[a,b]	15.7[b]	12.9	
Wear two sports bras					
Yes	5.8[a]	8.9a,b	9.8[a]	8.2	
No	84.4[a]	84.4[a]	78.2[b]	82.2	25.406*
Sometimes	9.8[a]	6.2[b]	12.1[a]	9.6	
Wear different sports bra styles for different sports/activities					
Yes	21.1[a]	17.7[a]	55.7[b]	32.8	329.440*
No	78.9[a]	82.3[a]	44.3[b]	67.2	

*denotes significant difference between countries at 0.05 level. Values in the same horizontal row not marked with the same superscript letter are significantly different at the 0.01 level

606 **Table IV.** For those that reported wearing a sports bra; when participants last purchased a sports bra
607 and how often participants replace their sports bra in the US (n = 795), UK (n = 705) and China (n =
608 870).

Sports bra purchase and replacement	Response (%)				χ^2
	US (n = 795)	UK (n = 705)	China (n = 870)	All (n = 2370)	
Sports bra purchase					
In the last month	22.6[a]	21.0[a]	46.6[b]	30.9	267.961*
Last three months	26.3[a]	29.2[a,b]	33.4[b]	29.8	
Last six months	14.1[a]	15.0[a]	8.7[b]	12.4	
Within the last year	16.7[a]	15.3[a]	5.6[b]	12.2	
Over a year ago	14.8[a]	14.6[a]	2.4[b]	10.2	
Can't remember	5.4[a]	4.8[a]	3.2[a]	4.4	
Sports bra replacement					
Every 3 months	11.4[a]	15.0[a]	51.7[b]	27.3	538.945*
Every 6 months	21.3[a]	25.5[a]	25.9[a]	24.2	
At least once a year	31.3[a]	29.5[a]	6.7[b]	21.7	
Over a year ago	15.8[a]	12.6[a]	4.1[b]	10.6	
I can't remember	13.8[a]	8.8[b]	8.0[b]	10.2	
I have never replaced my sports bra	6.3[a]	8.5[a]	3.6[b]	5.9	

609 *denotes significant difference between countries at 0.05 level. Values in the same horizontal row not
610 marked with the same superscript letter are significantly different at the 0.01 level
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613 **Table V.** For participants that report wearing a sports bra; sports bra preferences (%) for style,

614 components and colour in the US (n = 795), UK (n = 705) and China (n = 870).

	Preference (%)				
	US (n = 795)	**UK (n = 705)**	**China (n = 870)**	**All (n = 2370)**	**χ2**
Sports bra strap configuration					
Racer back	63.9[a]	53.9[b]	56.0[b]	58.0	17.685*
Cross-over	27.7[a]	23.8[a]	39.4[b]	30.8	50.044*
T-back	24.8[a]	16.6[b]	30.6[c]	24.5	41.232*
U-back	12.5[a]	14.6[a]	22.3[b]	16.7	32.113*
Vertical back	17.4[a]	15.3[a]	15.7[a]	16.2	1.320
Adjustable combination	10.2[a,b]	7.9[b]	12.5[a]	10.4	8.849*
No preference	14.2[a]	14.8[a]	9.0[b]	12.4	15.390*
Other	1.0	0.1	0.5	0.5	
Sports bra strap thickness					
Wide	58.7[a]	62.8[a]	59.2[a]	60.1	
Narrow	17.0[a]	13.9[a]	16.6[a]	15.9	4.036
No preference	24.3[a]	23.3[a]	24.3[a]	24.0	
Sports bra strap padding					
Thick (padded)	42.8[a]	51.2[b]	28.4[c]	40.0	
Thin	32.2[a]	22.6[b]	45.4[c]	34.2	114.594*
No preference	25.0[a]	26.2[a]	26.2[a]	25.8	
Adjustable shoulder straps and underband					
Yes	51.4[a]	58.4[b]	64.1[b]	58.2	
No	27.0[a]	17.9[b]	13.9[b]	19.5	50.532*
No preference	21.5[a]	23.7[a]	22.0[a]	22.3	
Underwire					
Yes	15.0[a]	21.1[b]	17.8[a,b]	17.8	
No	73.6[a]	62.4[b]	63.7[b]	66.6	30.997*
No preference	11.4[a]	16.5[b]	18.5[b]	15.5	
Padding/moulded cups					
Yes	43.4[a]	42.1[a]	62.6[b]	50.1	
No	41.3[a]	38.7[a]	18.3[b]	32.1	129.567*
No preference	15.3[a]	19.1[a]	19.1[a]	17.8	
Maximum coverage					
Yes	64.8[a]	71.5	0.0	43.0	
No	13.0[a]	5.8	68.6	27.9	1446.545*
I prefer low cut tops	12.6[a]	6.2	16.1	12.0	
No preference	19.6[a]	16.5	15.3	17.1	
Nipple concealment					
Essential	37.7[a]	31.8[b]	41.1[a]	37.2	
Very important	31.7[a]	30.9[a]	43.3[b]	35.7	122.281*
Important	15.5[a]	18.0[a]	10.2[b]	14.3	
Somewhat important	9.7[a]	10.5[a]	4.3[b]	7.9	

Not at all important	5.4[a]	8.8[a]	1.0[c]	4.8	
Sports bra colour					
No preference	32.5[a]	28.6[a]	29.3[a]	30.2	
Black	22.9[a]	32.3[b]	23.8[a]	26.0	
Multicolours	23.3[a]	17.0[b]	29.0[c]	23.5	55.640*
Bright neon colours	9.9[a]	7.5[a]	7.4[a]	8.3	
White	5.3[a]	8.8[b]	6.2[a,b]	6.7	
Nude	6.2[a]	5.8[a]	4.3[a]	5.4	

*denotes significant difference between countries at 0.05 level. Values in the same horizontal row not marked with the same superscript letter are significantly different at the 0.01 level

619 **Table VI.** Meanrank and rank order of important sports bra features (1 = most important, 10 = least
620 important) during moderate-intensity activities and vigorous-intensity activities reported by participants
621 in the US (n = 789), UK (n = 700) and China (n = 2356).

Sports bra feature	US (n = 789)	UK (n = 700)	China (n = 867)	All (n = 2356)
Importance during moderate-intensity activity				
Comfort	2.87[1]	3.08[1]	3.34[1]	3.11[1]
Support	3.63[3]	3.72[3]	4.38[2]	3.93[2]
Fit	3.52[2]	3.39[2]	4.76[3]	3.94[3]
Material	5.98[5]	6.10[7]	5.10[4]	5.69[4]
Price	5.07[4]	5.51[4]	6.70[9]	5.80[5]
Shape	6.09[6]	5.82[5]	5.95[6]	5.96[6]
Adjustability	6.36[8]	6.03[6]	5.58[5]	5.98[7]
Lift	6.27[7]	6.36[8]	6.03[7]	6.21[8]
Brand	7.69[10]	7.52[9]	6.26[8]	7.12[9]
Colour	7.50[9]	7.46[10]	6.89[10]	7.26[10]
Sports bra feature	**US (n = 608)**	**UK (n = 649)**	**China (n = 798)**	**All (n = 2055)**
Importance during vigorous-intensity activity				
Comfort	3.11[1]	3.42[2]	3.52[1]	3.37[1]
Support	4.02[3]	4.00[3]	4.65[2]	4.26[3]
Fit	3.12[2]	3.16[1]	4.70[3]	3.74[2]
Material	5.94[7]	6.27[8]	5.36[4]	5.82[6]
Adjustability	5.78[4]	6.19[7]	6.82[10]	6.32[8]
Lift	5.89[5]	5.81[6]	5.93[7]	5.88[7]
Shape	5.92[6]	5.67[4]	5.41[5]	5.64[4]
Price	5.99[8]	5.77[5]	5.56[6]	5.75[5]
Brand	7.62[10]	7.46[10]	6.34[8]	7.07[9]
Colour	7.61[9]	7.26[9]	6.70[9]	7.15[10]

622 Superscript numbers denote barrier rank order.
623
624

625 **Table VII.** For those that reported wearing a sports bra; the percentage of participants that
626 frequently wear each sports bra brand and the rank order of sports bra brands worn in the US
627 (n = 795), UK (n = 705) and China (n = 870).

Brand	Response (%)			
	US (n = 795)	**UK (n = 705)**	**China (n = 870)**	**All (n = 2370)**
Nike	40.9[1]	39.4[1]	39.1[1]	39.8[1]
Adidas	22.9[3]	27.0[2]	32.3[2]	27.6[2]
Under Armour	24.2[2]	8.5[10]	14.4[9]	15.9[3]
Victoria Secret	22.0[5]	7.0	12.5	14.1[4]
New Balance	14.1[8]	9.6[6]	16.3[4]	13.6[5]
Reebok	15.2[6]	15.7[3]	9.5	13.3[6]
Puma	9.1[9]	12.1[4]	15.4[6]	12.3[7]
Triumph	1.0	9.1[9]	21.0[3]	10.8[8]
Champion	22.4[4]	4.1	4.3	10.3[9]
H&M	5.0	11.6[5]	13.2[10]	10.0[10]
I don't know	14.2[7]	9.5[7]	3.3	8.8
Athleta	6.7[10]	1.3	7.2	5.3
Amoena	0.9	1.1	10.2	4.4
Shock Absorber	1.09	9.1[8]	2.6	4.0
Lululemon	4.2	2.0	3.9	3.4
Zella	1.8	1.8	5.7	3.2
Berlei	1.1	2.3	3.0	2.2
Freya Active	0.9	2.3	2.9	2.0
Title Nine	0.9	1.6	3.2	1.9
Brooks/Moving Comfort	1.5	1.1	2.5	1.8
Panache	1.1	1.8	2.2	1.7
Enell	0.8	1.6	2.2	1.5
Other	13.7	16.9	4.8	11.4
Decathlon	-	-	16.0[5]	5.9*
Anta	-	-	14.9[7]	5.5*
Li Ning	-	-	14.5[8]	5.3*
Xtep	-	-	11.0	4.1*

628 Superscript numbers denote brand rank
629 *denotes brands that were added for the China survey

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Table VIII. When participants were last professionally fitted for a sports bra in the US (n = 1060), UK (n = 1050) and China (n = 1037).

	Response (%)				
	US (n = 1060)	**UK (n = 1050)**	**China (n = 1037)**	**All (n = 3147)**	**χ^2**
Last professional sports bra fit					
In the last month	4.5[a]	4.7[a]	28.8[b]	12.6	
Last three months	6.6[a]	7.0[a]	25.0[b]	12.8	
Last six months	4.7[a]	6.1[a,b]	8.5[b]	6.4	
Within the last year	5.8[a]	4.9[a]	2.2[b]	4.4	800.942*
Over a year ago	6.7[a]	6.9[a]	5.0[a]	6.2	
Can't remember	6.0[a]	6.2[a,b]	8.9[b]	7.0	
I have never been fitted	65.6[a]	64.1[a]	21.6[b]	50.6	
Sports bra issues					
Shoulder straps dig into the skin	39.6[a]	32.5[a]	32.9[a]	35.1	6.025
Rubbing or chafing	26.1[a]	21.9[a]	33.6[b]	27.6	20.242*
Poor posture (as a result of bra use)	17.0[a]	17.1[a]	34.5[b]	23.1	93.298*
Underwire digs into skin	25.0[a]	20.0[a]	23.1[a]	22.8	3.594
Upper body muscle pain (as a result of bra use)	19.1[a]	20.3a,b	24.2[b]	21.3	9.664*
Other	13.0[a]	7.9[a]	10.1[a]	10.3	5.435

*denotes significant difference between countries at 0.05 level. Values in the same horizontal row not marked with the same superscript letter are significantly different at the 0.05 level